Fermi National Accelerator Laboratory

FN-280
7200.234

SEARCHES FOR CHARMED PARTICLES USING BUBBLE CHAMBERS

R. Harris

October 1975

Operated by Universities Research Association Inc. under contract with the Energy Research and Development Administration

FN-280
7200.234

SEARCHES FOR CHARMED PARTICLES USING BUBBLE CHAMBERS*

R. Harris
Fermi National Accelerator Laboratory
Batavia, Illinois 60510

ABSTRACT

Searches for charm particle production using bubble chambers are summarized. These searches depend on the detection of neutral strange particles. Upper limits are given for the different charmed mass regions and methods of search.

*Rappateur's talk presented at the Seattle meeting of the Division of Particles and Fields of the APS, 1975.

Several recent searches for charmed particles, summarized in Table I, have been made using bubble chambers with hadronic beams. These searches utilize the advantages of visible 4π geometry, relatively small biases and good detection of neutral particles through their "V" decays. Since charmed particles are expected to decay predominantly into strange particles, the detection of one or more neutral strange particles is an important feature of these experiments.

The various methods used to search for charmed particles, and resultant 95% confidence level upper limits, are summarized in Table II. To search for long-lived, visible particles ($\tau_c \gtrsim 10^{-11}$ sec)[5], the FSU group[2] has looked for two-prong V decays not fitting K_s^0, Λ or $\bar{\Lambda}$; these are candidates for $M_c^0 \to K^{\pm}\pi^{\mp}$. Out of ~10,000 V's, one such event was found whose mass as $K^{\pm}\pi^{\mp}$ is 1.926 ± 37 GeV and 1.988 ± 36 GeV. If this single event (which could have alternate explanations) is ignored, an upper limit of 0.2 μb is set.

Searches for short-lived particles have been made by searching for narrow resonances in mass distributions for $K_s^0(n\pi)$, $\Lambda(n\pi)$ and $\bar{\Lambda}(n\pi)$ with up to six pions. The Columbia group[1] reports upper limits in the range 1.5 - 3.7 μb for several exclusive channels, such as $\pi^+ p \to B_c^{++} + \bar{M}_c^0 + \pi^+$. These were determined by summing over all possible decay modes of the two charmed particles and examining scatter plots of the resulting mass combinations. Upper limits for inclusive channels, obtained by examining mass distributions for all possible $V^0(n\pi)$ combinations, are illustrated in Table II (see also Ref. 1). The results of the FNAL-FSU group[3] are based on the use of the FNAL 15' bubble chamber to search for events containing two or more neutral strange particles. This presents a method for enhancing the signal for charm-anticharm pair production (background is further restricted by requiring

TABLE I: EXPERIMENTAL PARAMETERS

Group	Interaction	E_{CM}	BC	# Events
1) Columbia-Binghampton[1]	π^+p	5.4 GeV	82"	15,233 K^0_S, Λ
2) FSU-Brandeis[2]	π^+d	7.7 GeV	82"	~ 10,000 Vs
3) FNAL-FSU[3]	π^-p	21.7 GeV	15'	36 double Vs (40% of film)
4) Davis-Krackow - Seattle-Warsaw[4]	π^-d	27.5 GeV	30"	72 μ triggers

TABLE II: TYPES OF SEARCH AND UPPER LIMITS (95% CL)

A) Long-lived states ($\tau_c \gtrsim 10^{-11}$ sec)
   1) $V^0 \rightarrow K^{\pm}\pi^{\mp}$ search
      - FSU[2]: $\sigma < 0.2$ μb

B) Short-lived states
   1) Exclusive channels: i.e., $\pi^+p \rightarrow p + M_c^+ + M_c^0$
      - Columbia[1]: $\sigma \lesssim 3.7$ μb (see Ref. 1)
   2) Inclusive channels: $C \rightarrow K\pi$, $K\pi\pi$, $\Lambda\pi$, $\Lambda\pi\pi$, etc.
      Representative upper limits:

Channel	Columbia[1]	FNAL-FSU[3]	FSU[2]
$K^0_s\pi^+\pi^-$	6 μb, at 2.5-4 GeV	40 μb, at 3.5 GeV	2 μb
$\Lambda\pi^+\pi^-$	4 μb, at 2.5-4 GeV	23 μb, at 3.5 GeV	2 μb
$\Lambda\pi^+\pi^-$	-	25 μb, at 3.5 GeV	-

C) Semi-leptonic Decay: $\mu + V$
   1) Davis-Krackow-Seattle-Warsaw[4]: $\sigma_{lim} \sim 300\text{-}500$ μb

that the $V^0\bar{V}^0$ mass be large, thus eliminating threshold $V\bar{V}^0$ production). However lack of statistics in this experiment (preliminary results) leads to limits in the 25-40 μb range.

The Davis-Krackow-Seattle-Warsaw experiment uses a muon detector in conjunction with the FNAL 30" chamber to search for semi-leptonic decays containing V^0s and μ's. The number of V^0s found per event is similar with or without the μ trigger. Unfolding the detection efficiency using a Monte Carlo, this leads to upper limits for $V^0 + \mu$ in the range 200 - 500 μb.

In summary, no evidence for charmed particle production is claimed in these experiments. The lower energy, high statistics experiments[1,2] have set strong upper limits for the lower charm mass ranges, whereas the higher energy experiments[3,4], are sensitive to higher mass ranges and to decay channels involving $\bar{\Lambda}$'s. Further analysis to increase the charm signal, and increased statistics in the higher mass ranges, should be forthcoming.

REFERENCES

[1] C. Baltay et al., Phys. Rev. Lett. 34, 1118 (1975).
[2] V. Hagopian et al., "Search for Charmed Mesons and Baryons," paper presented to this conference.
[3] R. Harris et al., "Search for Charm in 250 GeV/c $\pi^- p$ Interactions," paper presented to this conference.
[4] J. H. Klems et al., "A Search for Charmed Particle Production in $\pi^- d$ Interactions at 200 GeV/c", paper presented to this conference.
[5] An earlier search of this type was reported by T. Ferbel in D. A. Garelick, ed., Experimental Meson Spectroscopy - 1974 (AIP Conference Proceedings #21, N. Y., 1974), p. 393.